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Socioeconomic Position and Cognitive Function in the Seychelles: A Life Course Analysis

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Key Words

Socioeconomic factors · Cognitive function · Longitudinal studies

Abstract

Objective: Poorer socioeconomic conditions early in life have been linked with memory, attention and learning deficits in adulthood, as well as with specific areas of educational achievement. It remains unclear, however, whether these distal associations are mediated by more current socioeconomic factors. In this study, we sought to confirm the relation between early-life socioeconomic position (SEP) and adult cognitive function, and to examine potential mediation by contemporaneous SEP. ***Methods:*** Data from 463 young adults from the Main Cohort of the Seychelles Child Development Study were analyzed using subtests of the Cambridge Neurological Test Automated Battery and the Woodcock Johnson Test of Scholastic Achievement in relation to maternal Hollingshead Social Status Index scores at study enrollment (infancy), follow-up at 107 months, and follow-up at 17 years. ***Results:*** Findings include evidence of a link between infant-period SEP and 17-year memory, which was not mediated by childhood and 17-year SEP. Verbal and mathematical achievement at 17 years was associated with SEP at all points in the life course. ***Conclusions:*** SEP at different points during the young-adult life course may affect different cognitive domains later in life, which may provide targets for societal investment in ensuring adequate family resources throughout childhood and adolescence.

Introduction

It is well established that socioeconomic position (SEP) during infancy influences cognitive development in early childhood [1]. Neurodevelopmental research demonstrates that parental education and occupation during prenatal and infant periods correlate with early childhood general cognitive ability in addition to specific domains of cognition, including: mathematical ability, reasoning ability, working memory, executive function and spatial ability [2–6].

Far less epidemiologic research has explored the potential for early-life social and economic factors to influ-

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ence distal cognitive function in young and older adulthood [7–10]. This research is guided by the *life course* approach, which posits that disease states in adulthood can have origins in the complex interplay of social and biological factors from the gestational period, infancy and childhood [11]. It remains unclear what specific domains of adults' cognition are associated with early-life SEP and to what extent adult SEP mediates these associations. Tentatively, these studies suggest that poverty in infancy and early childhood is more detrimental to adult memory, learning, attention and general cognition than poverty in later childhood, adolescence and adulthood.

A 2009 review of studies examining the link between SEP and both childhood and adult cognition concluded that although the initial findings are suggestive of a relationship between early-life SEP and post-childhood cognition, these findings await confirmation [1]. This review suggested that future studies consider the inclusion of multiple, specific domains of cognition, rather than general measures. Furthermore, socioeconomic conditions at unique points in the life course may differentially predict the functioning of these domains.

We explored the links between SEP at multiple points in the life course with cognitive abilities evident at 17 years of age using data from the Seychelles Child Development Study (SCDS), paying particular attention to the predictive ability of SEP during infancy. We examined learning, memory, and attention domains of cognition in addition to multiple tests of academic achievement (verbal ability, mathematical ability). We also evaluated the extent to which childhood and young adult SEP mediate the relationship between infant SEP and these diverse outcomes.

Methods

Study Population

The SCDS is a prospective longitudinal cohort study of the association between prenatal methylmercury exposure from consumption of a diet high in fish during pregnancy and subsequent child neurodevelopment. The study is taking place in the Republic of Seychelles [12, 13]. The SCDS Main Cohort was enrolled in 1989–1990 and is comprised of half of the live births during that time period. A pediatric neurologist enrolled the cohort at 6 months of age. Eligibility criteria included living on the main island of Mahe and being within 1 month of their 6-month birthday. Infant exclusion criteria included being over 7 months of age, being non-Seychellois, or having had any of the following medical issues: low birth weight, seizures, congenital abnormalities, intracranial hemorrhage, meningitis, epilepsy, deafness, or head trauma with loss of consciousness. Maternal exclusion criteria included inadequate maternal hair to recapitulate methylmercury exposure during pregnancy, or a history of any of the following: alcoholism, attempted suicide, insulin-dependent diabetes, or eclampsia [14]. Informed consent was obtained from the designated caregiver of every participating child. The study protocol was approved by the University of Rochester's Research Subjects Review Board and the Seychelles Ethics Committee.

779 mother-child pairs were enrolled. After exclusions, 740 pairs were available for the initial evaluation at 6 months [13]. Sociodemographic data were collected and cognitive test batteries were conducted at 6, 19, 29, 66, and 107 months and at 10.5 and 17 years of follow-up. Of the 740 initially interviewed pairs, complete data on all relevant socioeconomic, cognitive, and covariate information were available for 463 (63%) pairs at the 17-year follow-up. Details regarding study recruitment, data collection, and timeline are described at length elsewhere [12, 13].

Life Course SEP

Information on the mother's and father's occupation and education was collected at each visit. Due to the fluid and complex household dynamics in the Seychelles, and the relative consistency of maternal presence from early life to young adulthood, we focused exclusively on maternal SEP. We operationalized maternal SEP through the use of the Hollingshead Social Status Index [15], which was modified for the use of employment codes relevant to the Republic of Seychelles [16]. We combined occupational and educational codes through a weighted formula into a continuous Hollingshead Index with a maximum score of 65 [16]. In this analysis, we consider Hollingshead scores at only three time points: 6 months (enrollment), 107 months, and 17 years. We focus, in particular, on 6-month Hollingshead scores in all analyses. These three time points were chosen to allow for adequate variability in SEP over time.

17-Year Cognitive Measures

We considered multiple dimensions of 17-year-old cognitive ability and scholastic achievement through the following two standardized tests: subtests from the Cambridge Neurological Test Automated Battery (CANTAB) and the Woodcock Johnson Tests of Achievement (WJTA). Both tests are standardized, validated, and have a history of use in epidemiologic and clinical studies [17, 18].

Child development specialists, who were trained in the testing process, administered the test battery. Participants were directed to a touch-screen monitor to receive an explanation of CANTAB test procedures and were subsequently instructed to complete a simple task (touching the center point of flashing crosses on the screen) prior to starting the series of tests. The CANTAB 'learning and reverse learning' domain included the Intra-Extra Dimensional Shift (IED) test and the Paired Associate Learning (PAL) test. The CANTAB 'attention' domain was represented by the simple reaction time (RTI) test and the Rapid Visual Information Processing (RVP) test. 'Memory' was measured using the CANTAB Delayed Match to Sample (DMS) test, the Pattern Recognition Memory (PRM) test, the Spatial Recognition Memory (SRM) test, and the Spatial Working Memory (SWM) test. The WJTA provided scores for academic achievement in the following areas: passage comprehension, arithmetic calculation, letter-word identification, applied mathematical problem solving and math fluency.

Test materials and instructions were initially translated into Creole language, tested in the Seychelles, and then administered to subjects. The WJTA test covers basic academic skills, which

Table 1. Descriptive statistics of continuous Hollingshead scores, CANTAB, and WJTA outcomes at 6 months, 107 months and 17 years

	Means ± SEMs
Hollingshead scores	
6 months	24.7 ± 0.6 (17, 19, 33)
107 months	24.3 ± 0.6 (14, 20, 35)
17 years	31.6 ± 0.7 (19, 29, 42)
CANTAB learning/reverse learning outcomes	
log (IED total trials)	4.7 ± 0.02 (4.4, 4.7, 5.0)
log (IED pre-ED errors)	2.2 ± 0.02 (1.8, 2.1, 2.4)
log (PAL total errors + 1)	2.1 ± 0.04 (1.6, 2.1, 2.6)
PAL stages completed	6.0 ± 0.04 (5, 6, 7)
CANTAB attention outcomes	
log (RTI simple reaction time)	5.7 ± 0.01 (5.6, 5.7, 5.8)
RVP total misses	14.0 ± 0.2 (10, 14, 18)
log (RVP total false alarms + 1)	1.0 ± 0.04 (0.7, 1.1, 1.4)
CANTAB memory outcomes	
DMS, % correct (12,000-ms delay)	7.7 (7, 8, 9)
PRM, % correct	85.9 (79.2, 87.5, 95.8)
SRM, % correct	80.6 (75, 80, 85)
Sqrt (SWM within errors)	1.0 ± 0.05 (0, 1.0, 1.7)
Sqrt (SWM total errors)	5.0 ± 0.08 (3.9, 5.1, 6.2)
WJTA outcomes	
Passage comprehension	76.4 ± 1.0 (65, 78, 88)
Calculation	85.3 ± 0.8 (73, 86, 95)
Letter-word identification	100.3 ± 1.3 (91, 104, 119)
Applied problems	86.2 ± 0.7 (79, 86, 95)
Math fluency	73.1 ± 0.6 (65, 73, 81)

Figures in parentheses are 25th percentile, median and 75th percentile.

were appropriate for the Seychelles school curriculum. The test administration time for the CANTAB test was approximately 1 h. The WJTA test lasted approximately 30 min.

Statistical Analysis

We considered the maternal Hollingshead scores at three points in the SCDS timeline: 6 months, 107 months and 17 years. To assess colinearity among these independent variables, we generated a Spearman rank correlation matrix. Because we were interested in the global effect of SEP regardless of potential confounders or mediators that may be correlated with SEP, only child sex and color blindness were included as covariates in all the following analyses. Simple descriptive statistics illustrating covariate values across all SCDS 17-year cognitive outcomes will be presented elsewhere [Davidson et al., in preparation]. Means with standard errors as well as distribution quartiles were calculated for all distinct Hollingshead scores, and unstandardized cognitive and academic achievement measures. To examine potential bias due to the exclusion of subjects with missing data, we conducted a two-sample t test to compare 6-month Hollingshead scores among the included and excluded subjects. No significant difference was noted (p = 0.58).

Regression results are presented separately for learning/reversal learning, attention, memory, and academic achievement categories. For each test outcome, parameter estimates with 95% confidence intervals are presented for each of the three temporally distinct Hollingshead scores. Sex by Hollingshead interactions were investigated within these initial regression models because of prior evidence suggesting that substantial sex differences exist in specific cognitive abilities throughout the life course [19, 20]. To more closely examine whether later SEP mediates the putative association between 6-month Hollingshead scores and 17-year cognition, we conducted a modified version of Sobel's test for mediation [21]. Child sex and color blindness were adjusted for within each test of mediation.

Within each 6-month Hollingshead and test outcome pair, two nested model results are presented: (1) the association between that Hollingshead score and cognitive outcome adjusting for child sex and child color blindness, and (2) the association adjusting for the above covariates in addition to 107-month and 17-year Hollingshead scores. Tests of mediation were conducted for potential mediation by 107-month and 17-year SEP. The percent of the 6-month and 17-year cognitive outcome association that was mediated by 107-month and 17-year SEP is presented (calculated as the percentage change in coefficient before and after controlling for later SEP). Multiple linear regression assumptions were graphically verified for every model. Based on the results of these diagnostic procedures, cognitive test scores were transformed accordingly. In addition to this transformation, all outcomes were standardized to Z-score values (based on mean scores and standard deviations of each test outcome) to permit direct comparison of effect sizes between different tests. All analyses were performed with R 2.10.1 (R Foundation for Statistical Computing, Vienna, Austria).

Results

The complete sample of 463 participants consisted of 239 (51.6%) females and 224 (48.3%) males. Five participants were identified as having any form of color blindness. Spearman rank correlations between the three temporally distinct maternal Hollingshead scores demonstrated that the variation within any given Hollingshead score explained less than half of the variation for the other scores, suggesting that multi-colinearity in the context of regression modeling was not be problematic. Table 1 provides descriptive statistics on all Hollingshead scores and outcome measures.

Regression results for each temporally distinct Hollingshead score are shown in table 2. For all significant associations described below, higher maternal SEP as indicated by Hollingshead scores was associated with better performance on tests. No statistically significant interactions were noted for any outcome and Hollingshead score pair. Accordingly, only main-effects models are reported.

Table 2. Associations between continuous Hollingshead scores and standardized CANTAB and WJTA outcomes

Outcomes	Regression β-coefficient (95% CI)[1, 2]		
	6-month Hollingshead	107-month Hollingshead	17-year Hollingshead
CANTAB learning/reverse learning outcomes			
log (IED total trials)	–0.004 (–0.012, 0.004)	–0.004 (–0.012, 0.004)	**–0.007 (–0.013, –0.001)**
log (IED pre-ED errors)	**–0.008 (–0.016, 0)**	–0.007 (–0.015, 0.001)	–0.003 (–0.009, 0.003)
log (PAL total errors + 1)	–0.008 (–0.016, 0)	–0.007 (–0.015, 0.001)	**–0.008 (–0.014, –0.002)**
PAL stages completed	**0.009 (0.001, 0.017)**	**0.009 (0.001, 0.017)**	**0.008 (0.002, 0.014)**
CANTAB attention outcomes			
log (RTI simple reaction time)	–0.002 (–0.01, 0.006)	0 (–0.008, 0.008)	**–0.006 (–0.012, 0)**
RVP total misses	**–0.011 (–0.02, –0.005)**	**–0.009 (–0.017, –0.001)**	**–0.011 (–0.017, –0.005)**
log (RVP total false alarms + 1)	–0.006 (–0.014, 0.002)	–0.004 (–0.012, 0.004)	–0.003 (–0.009, 0.003)
CANTAB memory outcomes			
DMS, % correct (12,000-ms delay)	**0.01 (0.004, 0.016)**	0.007 (–0.001, 0.015)	**0.006 (0, 0.012)**
PRM, % correct	0.007 (–0.001, 0.015)	0.004 (–0.004, 0.012)	**0.009 (0.003, 0.015)**
SRM, % correct	**0.011 (0.005, 0.017)**	0.007 (–0.001, 0.015)	0.005 (–0.001, 0.011)
Sqrt (SWM within errors)	–0.003 (–0.011, 0.005)	**–0.008 (–0.016, 0)**	0 (–0.006, 0.006)
Sqrt (SWM total errors)	**–0.012 (–0.02, –0.006)**	**–0.008 (–0.016, 0)**	–0.006 (–0.012, 0)
WJTA outcomes			
Passage comprehension	**0.018 (0.01, 0.026)**	**0.015 (0.007, 0.023)**	**0.018 (0.012, 0.024)**
Calculation	**0.02 (0.014, 0.026)**	**0.016 (0.008, 0.024)**	**0.015 (0.009, 0.021)**
Letter-word identification	**0.016 (0.008, 0.024)**	**0.011 (0.003, 0.019)**	**0.016 (0.01, 0.022)**
Applied problems	**0.02 (0.014, 0.026)**	**0.014 (0.006, 0.022)**	**0.017 (0.011, 0.023)**
Math fluency	**0.018 (0.012, 0.024)**	**0.009 (0.003, 0.015)**	**0.012 (0.006, 0.018)**

Figures in parentheses are 95% CI.
[1] Bold font indicates significance at the 0.05 level. [2] Covariates: color blindness, child's sex.

Starting with the learning/reversal learning outcomes, the number of PAL stages completed was associated with each Hollingshead score. The number of errors on the IED pre-ED shift test was associated only with 6-month Hollingshead. In addition to the number of PAL stages completed, both the IED trials completed and the PAL total errors were associated with 17-year Hollingshead. Among attention outcomes, the RVP total misses were associated with the 6-month, 107-month, and 17-year Hollingshead scores. The RTI simple reaction time test was associated with 17-year Hollingshead scores only. The majority of memory outcomes were associated with 6-month Hollingshead scores, including the DMS, SRM, and the SWM total trials outcomes. Both of the SWM outcomes were associated with 107-month Hollingshead. The DSM and PRM outcomes were both related to 17-year Hollingshead. All scholastic achievement tests were significant for each of the three Hollingshead measures. The magnitude of these associations was higher for these scholastic achievement tests than were the associations found for any of the above domains measured by CANTAB.

Table 3 provides a closer examination of the role that 107-month and 17-year Hollingshead scores could play in mediating the associations between the Hollingshead score at 6 months and outcomes. After adjusting for 107-month and 17-year Hollingshead scores, all learning/reversal learning outcomes lost significance although mediation did not explain a substantial portion of the relationship. The only attention outcome associated with Hollingshead scores at 6 months (RVP) was significantly mediated by 17-year Hollingshead scores (45.5% of association explained by 17-year Hollingshead scores). After adjusting for 107-month and 17-year Hollingshead scores, only the within-error SRM memory scores remained significant, with no substantial mediation occurring. The DMS outcome was only marginally insignificant after adjustment for contemporary Hollingshead scores. Associations that lost significance did not appear to be mediated by eventual Hollingshead scores. Finally, all scholastic

Table 3. Associations between continuous 6-month Hollingshead scores and standardized CANTAB and WJTA outcomes with analysis of mediation

Outcomes	Regression β-coefficient (95% CI)[1]		Mediation test: % of association explained by mediator (p value)[1]	
	6-month Hollingshead[2]	6-month Hollingshead[3]	mediation by 107-month Hollingshead	mediation by 17-year Hollingshead
CANTAB learning/reverse learning outcomes				
log (IED total trials)	–0.004 (–0.012, 0.004)	0.001 (–0.009, 0.011)	39.2% (0.66)	86.6% (0.06)
log (IED pre-ED errors)	**–0.008 (–0.016, 0)**	–0.006 (–0.016, 0.004)	19.1% (0.70)	3.4% (0.89)
log (PAL total errors + 1)	–0.008 (–0.016, 0)	–0.004 (–0.014, 0.006)	14.4% (0.75)	37.9% (0.10)
PAL stages completed	**0.009 (0.001, 0.017)**	0.004 (–0.006, 0.014)	31.1% (0.45)	29.2% (0.17)
CANTAB attention outcomes				
log (RTI simple reaction time)	–0.002 (–0.01, 0.006)	–0.001 (–0.011, 0.009)	109.1% (0.49)	148.9% (0.07)
RVP total misses	**–0.011 (–0.02, –0.005)**	–0.004 (–0.014, 0.006)	20.0% (0.56)	**45.5% (0.01)**
Log (RVP total false alarms + 1)	–0.006 (–0.014, 0.002)	–0.008 (–0.018, 0.002)	17.4% (0.77)	1.9% (0.95)
CANTAB memory outcomes				
DMS, % correct (12,000-ms delay)	0.01 (0.004, 0.016)	0.009 (–0.001, 0.019)	1.1% (0.98)	10.0% (0.62)
PRM, % correct	0.007 (–0.001, 0.015)	0.004 (–0.006, 0.014)	18.0% (0.75)	62.4% (0.03)
SRM, % correct	**0.011 (0.005, 0.017)**	**0.012 (0.002, 0.022)**	13.4% (0.70)	6.0% (0.73)
Sqrt (SWM within errors)	–0.003 (–0.011, 0.005)	0.005 (–0.005, 0.015)	**288.5% (0.03)**	27.2% (0.68)
Sqrt (SWM total errors)	**–0.012 (–0.02, –0.006)**	–0.012 (–0.022, –0.002)	5.2% (0.87)	5.9% (0.71)
WJTA outcomes				
Passage comprehension	**0.018 (0.01, 0.026)**	0.008 (–0.004, 0.02)	14.7% (0.50)	**41.4% (0.0004)**
Calculation	**0.02 (0.014, 0.026)**	**0.015 (0.005, 0.025)**	6.7% (0.71)	**21.3% (0.02)**
Letter-word identification	**0.016 (0.008, 0.024)**	**0.012 (0.002, 0.022)**	10.2% (0.66)	**40.0% (0.001)**
Applied problems	**0.02 (0.014, 0.026)**	**0.014 (0.004, 0.024)**	4.2% (0.83)	**32.0% (0.002)**
Math fluency	**0.018 (0.012, 0.024)**	**0.02 (0.01, 0.03)**	30.9% (0.12)	19.8% (0.06)

Figures in parentheses are 95% CI.
[1] Bold font indicates significance at the 0.05 level. [2] Adjusting for child's sex and color blindness. [3] Adjusting for child's sex, color blindness, 107-month, and 17-year maternal Hollingshead score.

achievement outcomes except for reading comprehension remained significant after adjustment for 107-month and 17-year Hollingshead scores. At the same time, mediation by 17-year occurred for the majority of WJTA scores.

Discussion

The purpose of this life course analysis was to explore the link between early-life maternal social and economic conditions with 17-year cognitive functions of their children, paying particular attention to the mediating effects of post-infancy conditions on separate domains of cognition. The results of this analysis suggest that both learning/reversal learning and attention are primarily influenced by contemporary SEP. We noted modest evidence of a link between infant-period SEP and 17-year memory, independent of childhood and 17-year socioeconomic position. Finally, SEP at multiple points in the life course was predictive of both verbal and mathematical achievement at 17 years of age. As a whole, these results suggest that SEP at different points during the young-adult life course may affect unique cognitive domains later in life.

Few studies have examined how life course socioeconomic conditions relate to adult cognitive ability. After adjusting for the participants' own educational attainment, Kaplan et al. [7] noted significant links between the childhood SEP and perceptual motor speed, memory, learning ability and constructional ability. No independent associations were noted for general language ability or general cognitive function. Richards and Wadsworth [9] took a different approach by examining cognitive and achievement outcomes at multiple points in the life course. The investigators noted that greater social adversity was linked to lower reading/verbal achievement from adolescence and extending into middle age. Early life adversity was also linked to memory deficits in middle age. However, a structural equation modeling analysis of the Whitehall II study did not lend support to these findings [10]. This analysis revealed that adult SEP better explains adult cognition than early-life SEP. However, all of the cognitive outcomes of the Whitehall II analysis were collapsed into one construct, making it impossible to determine whether different cognitive domains were influenced by SEP at different time points.

Our findings are in partial agreement with those of the prior studies. Our analysis supports prior studies with regard to an independent link between infant-period SEP and 17-year memory function. However, unlike the three previous studies, our results suggest that some measures of learning and attentional ability are linked with contemporaneous SEP. Our results also demonstrate that for some cognitive domains, links with early-life SEP are driven by later SEP. Specifically, associations of early life SEP with attention and academic achievement are at least partially mediated by contemporaneous SEP. This suggests that brains structures, such as the parietal lobe, may withstand long-term alterations resulting from early-life stress and conditions.

Each of the cognitive domains we examined is directed by unique structures of the brain, and accordingly our results suggest that socioeconomic conditions in early life differently affect these structures. Two different mechanisms may account for the independent association between early-life social factors and young-adult memory. The first could be characterized as the biological imprinting of stress during critical periods in development [22–24]. At the anatomic and physiologic level, this might be explained through overactivity of the hypothalamic-pituitary-adrenal (HPA) axis, the neuroendocrine system that mediates the body's response to stress [25]. Recent work with rats suggests that early-life stress can cause physiologic changes in the HPA axis that promote chronic hypersecretion of cortisol, hippocampal neurogenesis and decreased HPA hormone receptor density in the hippocampus, all of which appear to persist into adulthood [26, 27].

Alternatively, SEP could exert distal effects on cognition not through the internalization of stress, but through proxy factors, such as the availability of caretakers to nurture and stimulate infants and children. More specifically, early-life SEP is related to parenting style, investment in the child's education, intellectual stimulation, and mentorship quality, all of which, in turn, are related to cognitive development [28, 29].

Several strengths are present in this analysis. This is the first analysis on this topic to employ a well-recognized test of mediation to more closely examine how contemporary SEP might mediate the early-life SEP and adult cognition association [30]. Although further insight can be gained by newer statistical approaches (structural equation modeling and marginal structural models) [31], the method we employed arguably allows for more straightforward and familiar interpretation of mediation effects [30]. Additionally, we employed well-validated, standardized tests of cognition and achievement, examining specific dimensions such as memory with multiple tests, instead of relying on general cognitive outcomes. Finally, the prospective evaluation of SEP allowed us to avoid issues relating to recall bias. Notable limitations are present, however. For instance, the SCDS only collected educational attainment and occupation socioeconomic information. Therefore, this study could not explore how other dimensions of SEP relate to young adult cognition. Additionally, without multiple assessments of the cognition and academic achievement domains over time, we are unable to provide a clearer picture of the potentially dynamic relationship between SEP and cognition throughout the 17 years of study time. Finally, the present analysis only included 63% of the original mother-infant pairs, largely due to missing data; however, we did not note a significant difference among the included and excluded participants with regard to socioeconomic factors.

In conclusion, our findings suggest that programs providing resources to new families living in less than optimal social and economic conditions may beneficially affect children's cognition. More longitudinal studies that expand the number of tested cognitive domains and tease apart mediation effects are needed to confirm our observations.

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Disclosure Statement

No conflicts of interest.

References

1 Hackman DA, Farah MJ: Socioeconomic status and the developing brain. Trends Cogn Sci 2009;13:65–73.

2 Turkheimer E, Haley A, Waldron M, D'Onofrio B, Gottesman II: Socioeconomic status modifies heritability of IQ in young children. Psychol Sci 2003;14:623–628.

3 Tong S, Baghurst P, Vimpani G, McMichael A: Socioeconomic position, maternal IQ, home environment, and cognitive development. J Pediatr 2007;151:284–288, 8 e1.

4 Kiernan KE, Huerta MC: Economic deprivation, maternal depression, parenting and children's cognitive and emotional development in early childhood. Br J Sociol 2008;59: 783–806.

5 Hillemeier MM, Farkas G, Morgan PL, Martin MA, Maczuga SA: Disparities in the prevalence of cognitive delay: how early do they appear? Paediatr Perinat Epidemiol 2009;23: 186–198.

6 Farah MJ, Shera DM, Savage JH, Betancourt L, Giannetta JM, Brodsky NL, Malmud EK, Hurt H: Childhood poverty: specific associations with neurocognitive development. Brain Res 2006;1110:166–174.

7 Kaplan GA, Turrell G, Lynch JW, Everson SA, Helkala EL, Salonen JT: Childhood socioeconomic position and cognitive function in adulthood. Int J Epidemiol 2001;30: 256–263.

8 Turrell G, Lynch JW, Kaplan GA, Everson SA, Helkala EL, Kauhanen J, Salonen JT: Socioeconomic position across the lifecourse and cognitive function in late middle age. J Gerontol B Psychol Sci Soc Sci 2002;57:S43–S51.

9 Richards M, Wadsworth ME: Long term effects of early adversity on cognitive function. Arch Dis Child 2004;89:922–927.

10 Singh-Manoux A, Richards M, Marmot M: Socioeconomic position across the lifecourse: how does it relate to cognitive function in mid-life? Ann Epidemiol 2005;15: 572–578.

11 Kuh D, Ben-Shlomo Y: A life course approach to chronic disease epidemiology. Oxford, Oxford University Press, 1997.

12 Marsh DO, Clarkson TW, Myers GJ, Davidson PW, Cox C, Cernichiari E, Tanner MA, Lednar W, Shamlaye C, Choisy O, et al: The Seychelles study of fetal methylmercury exposure and child development: introduction. Neurotoxicology 1995;16:583–596.

13 Davidson PW, Myers GJ, Cox C, Wilding GE, Shamlaye CF, Huang LS, Cernichiari E, Sloane-Reeves J, Palumbo D, Clarkson TW: Methylmercury and neurodevelopment: longitudinal analysis of the Seychelles child development cohort. Neurotoxicol Teratol 2006;28:529–535.

14 Davidson PW: The Child Development Studies in Seychelles: Principles of studying low-level neurotoxic exposures in children: using the Seychelles Child Development Study of methyl mercury as a prototype. Seychelles Med Dental J 2004;7:84–99.

15 Hollingshead AB: Four factor index of social status. New Haven, Department of Sociology, Yale University, 1975.

16 Davidson PW, Myers GJ, Cox C, Axtell C, Shamlaye C, Sloane-Reeves J, Cernichiari E, Needham L, Choi A, Wang Y, Berlin M, Clarkson TW: Effects of prenatal and postnatal methylmercury exposure from fish consumption on neurodevelopment: outcomes at 66 months of age in the Seychelles Child Development Study. JAMA 1998;280: 701–707.

17 Luciana M: Practitioner review: computerized assessment of neuropsychological function in children: clinical and research applications of the Cambridge Neuropsychological Testing Automated Battery (CANTAB). J Child Psychol Psychiatry 2003;44:649–663.

18 Woodcock RW, McGrew KS, Mather N: Woodcock-Johnson III Tests of Achievement, Itasca, 2001.

19 Read S, Pedersen NL, Gatz M, Berg S, Vuoksimaa E, Malmberg B, Johansson B, McClearn GE: Sex differences after all those years? Heritability of cognitive abilities in old age. J Gerontol B Psychol Sci Soc Sci 2006; 61:P137–P143.

20 Froehlich TE, Lanphear BP, Dietrich KN, Cory-Slechta DA, Wang N, Kahn RS: Interactive effects of a DRD4 polymorphism, lead, and sex on executive functions in children. Biol Psychiatry 2007;62:243–249.

21 Sobel ME: Asymptotic confidence intervals for indirect effects in structural equation models; in Leinhardt S (ed): Sociological Methodology. Washington, American Sociological Association, 1982, pp 290–312.

22 Ramey CT, Ramey SL: Prevention of intellectual disabilities: early interventions to improve cognitive development. Prev Med 1998;27:224–232.

23 Hertzman C: The biological embedding of early experience and its effects on health in adulthood. Ann NY Acad Sci 1999;896:85–95.

24 Hertzman C, Wiens M: Child development and long-term outcomes: a population health perspective and summary of successful interventions. Soc Sci Med 1996;43:1083–1095.

25 Fulford AJ, Harbuz MS: An Introduction to the HPA axis. I. The Neurobiology of Stress; in Steckler T, Kalin NH, Reul JMHM (eds): Handbook on Stress and the Brain. Amsterdam, Elsevier, 2004.

26 Aisa B, Tordera R, Lasheras B, Del Rio J, Ramirez MJ: Cognitive impairment associated to HPA axis hyperactivity after maternal separation in rats. Psychoneuroendocrinology 2007;32:256–266.

27 Huot RL, Plotsky PM, Lenox RH, McNamara RK: Neonatal maternal separation reduces hippocampal mossy fiber density in adult Long Evans rats. Brain Res 2002;950:52–63.

28 Guo G, Harris KM: The mechanisms mediating the effects of poverty on children's intellectual development. Demography 2000; 37:431–447.

29 Power C, Jefferis BJ, Manor O, Hertzman C: The influence of birth weight and socioeconomic position on cognitive development: does the early home and learning environment modify their effects? J Pediatr 2006; 148:54–61.

30 Baron RM, Kenny DA: The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. J Pers Soc Psychol 1986;51:1173–1182.

31 VanderWeele TJ: Marginal structural models for the estimation of direct and indirect effects. Epidemiology 2009;20:18–26.